

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# **Creation and Implementation of Customised Production Scheduling Software in a Processed Cheese Factory**

A thesis presented in partial fulfilment of the  
requirements for the degree of

**Master of Technology  
in  
Manufacturing and Industrial Technology**

at Massey University, Palmerston North,  
New Zealand

**Ross Aiken  
2000**

## **Abstract**

This project investigated creating computer algorithms and friendly software interfaces to assist with the scheduling of single stage operations with sequence dependant set-ups and crew rostering problems across multiple lines.

Various techniques and approaches were investigated for reducing the total solution space including, grouping similar items and orders and bucket scheduling. The principles of the Goldratt Method of Scheduling were used.

A Tabu Search algorithm was implemented to search for solutions where total make-span was minimised and probability of missing orders was taken into account in an unreliable production system.

*Microsoft Access* and *Microsoft Visual Basic* were used to create a stand alone application that interfaced with an Manufacturing Resource Planning system.

# Table of Contents

<u>Abstract</u> .....	i
<u>Table of Contents</u> .....	ii
<u>Table of Figures</u> .....	vii
<u>List of Tables</u> .....	viii
<u>Chapter 1 - Introduction</u> .....	viii
<u>1.1 - Overview</u> .....	1
<u>1.2 - The Project's Specific Goals</u> .....	1
<u>1.3 - Structure of this Report</u> .....	2
<u>1.4 - Introduction to Pastoral Foods (NZ) Limited</u> .....	3
<u>1.4.1 - Background to the Need for the Project</u> .....	3
<u>1.4.2 - Manufacturing Facilities and Products</u> .....	5
<u>1.4.3 - The Scheduling Problem</u> .....	7
<u>1.5 - Scheduling In New Zealand</u> .....	9
<u>Chapter 2 - Computer Programming Systems</u> .....	10
<u>2.1 - Overview</u> .....	10
<u>2.2 - Database and Programming Systems</u> .....	10
<u>2.3 - MRP-II Systems and Interfaces</u> .....	10
<u>Chapter 3 - Scheduling Techniques and Systems</u> .....	11
<u>3.1 - Overview</u> .....	11
<u>3.2 - Levels of Planning</u> .....	11
<u>3.2.1 - Overview</u> .....	11
<u>3.2.2 - Long Range Forecasts and Rough Cut Capacity Planning</u> .....	12
<u>3.2.3 - Master Production Scheduling</u> .....	12
<u>3.2.4 - Shop Floor Control</u> .....	13
<u>3.3 - Simplification of Scheduling of Complex Processes</u> .....	15
<u>3.4 - Scheduling Objective Functions</u> .....	16
<u>3.5 - Sequencing</u> .....	19
<u>3.6 - Sequence Dependant Set-Ups</u> .....	20
<u>3.6.1 - Overview</u> .....	20
<u>3.6.2 - Standard Sequence</u> .....	21
<u>3.6.3 - Conditional Standard Sequence</u> .....	21
<u>3.6.4 - Trial and Error Calculated Sequence</u> .....	21

<u>3.6.5 - Combinations of Sequencing Techniques</u> .....	23
<u>3.7 - Grouping Similar Items</u> .....	23
<u>3.8 - Crew Rostering</u> .....	25
<u>3.9 - Time Management Techniques</u> .....	26
<u>3.9.1 - Overview</u> .....	26
<u>3.9.2 - Continuous Time Line Scheduling</u> .....	27
<u>3.9.3 - Bucket Scheduling</u> .....	27
<u>3.10 - Scheduling Systems with MRP-II</u> .....	29
<u>3.10.1 - Overview</u> .....	29
<u>3.10.2 - Master Production Schedule Program</u> .....	30
<u>3.11 - Scheduling Systems without MRP-II</u> .....	32
<u>Chapter 4 - Multistage Scheduling Techniques</u> .....	33
<u>4.1 - Overview</u> .....	33
<u>4.2 - Forecast Myopic Dispatch Method</u> .....	33
<u>4.3 - OPT / Goldratt Scheduling Method</u> .....	34
<u>Chapter 5 - Techniques in Searching for Solutions</u> .....	35
<u>5.1 - Overview</u> .....	35
<u>5.1.1 - The Size of the Problem</u> .....	35
<u>5.1.2 - Techniques Available</u> .....	36
<u>5.1.3 - Effects of Sequence Dependant Set-Ups</u> .....	36
<u>5.1.4 - Visibility Problems</u> .....	37
<u>5.1.5 - Measuring Results</u> .....	37
<u>5.2 - Complete Enumeration</u> .....	38
<u>5.3 - Branch and Bound</u> .....	40
<u>5.4 - Random Pair-Wise Interchange</u> .....	42
<u>5.5 - Tabu Search</u> .....	45
<u>5.6 - Individual Group Enumeration</u> .....	50
<u>5.7 - Combination Individual Group Enumeration and Tabu Search</u> .....	51
<u>Chapter 6 - Data Collection Methods</u> .....	53
<u>6.1 - Overview</u> .....	53
<u>6.2 - Collecting Production Rates v Machines</u> .....	54
<u>6.3 - Collecting Changeover Times</u> .....	55
<u>Chapter 7 - Immunity from Disruption</u> .....	58
<u>7.1 - Overview</u> .....	58

<u>7.2 - Shipping Buffers</u> .....	58
<u>7.3 - Time and Space Buffers</u> .....	59
<u>7.4 - Avoiding Vulnerability to Missing Orders</u> .....	59
<u>7.5 - Available to Promise</u> .....	62
<u>Chapter 8 - Raw Material Availability</u> .....	63
<u>Chapter 9 - Optimisation Macros (Automatic Solutions)</u> .....	64
<u>Chapter 10 - Visual Interfaces (Manual Solutions)</u> .....	66
<u>10.1 - Overview</u> .....	66
<u>10.2 - Gantt Charts</u> .....	66
<u>10.3 - Adjustable Summary Tables</u> .....	68
<u>10.4 - Case Study - Use of Adjustable Summary Table</u> .....	71
<u>Chapter 11 - Over-All Solutions</u> .....	73
<u>11.1 - Overview</u> .....	73
<u>11.2 - Procedure of the System's Operation</u> .....	74
<u>11.2.1 - Obtain a Customer Order Listing</u> .....	75
<u>11.2.2 - Display Capacity Constraints and Restrictions for Each</u> <u>Bucket</u> .....	76
<u>11.2.3 - Adjust Capacity Constraints and Restrictions for Each Bucket</u> .....	77
<u>11.2.4 - Run the Automatic Schedule Optimisation Macro</u> .....	77
<u>11.2.5 - Inspect and Adjust Schedule</u> .....	78
<u>11.2.6 - Check for Raw Material Availability</u> .....	78
<u>11.2.7 - Adjust Schedule in Accordance with Raw Material</u> <u>Availability</u> .....	79
<u>11.2.8 - Feed Back Exception Information</u> .....	79
<u>11.2.9 - Output the Schedule to Manufacturing</u> .....	79
<u>11.3 - Procedure for Accepting New Customer Orders</u> .....	80
<u>11.3.1 - Obtain a List of Unmatched Customer Orders</u> .....	80
<u>11.3.2 - Available to Promise Capacity Constraints and Restrictions</u> .....	80
<u>11.3.3 - Decide what Extra Orders to Plan</u> .....	81
<u>11.3.4 - Create Shop Orders and/or Firm Planned Orders for Orders</u> .....	81
<u>11.4 - Coping with Changes in Requirements</u> .....	82
<u>11.5 - Future Work</u> .....	82
<u>Chapter 12 - Discussion and Conclusions</u> .....	85
<u>12.1 - Overview</u> .....	85

<u>12.2 - Operators View</u> .....	86
<u>12.3 - Outcomes for Pastoral Foods</u> .....	86
<u>Appendix 1 - Pastoral Foods (NZ) Limited List of Items</u> .....	88
<u>1.1 - Individually Wrapped Slices - List of Items</u> .....	88
<u>1.2 - Slice on Slice - List of Items</u> .....	91
<u>1.3 - Cheez Toyz/Bodz - List of Items</u> .....	91
<u>1.4 - Cheese Spreads - List of Items</u> .....	92
<u>1.5 - Packets (250g) - List of Items</u> .....	92
<u>1.6 - Blocks (20kg) - List of Items</u> .....	92
<u>1.7 - Blocks (2kg) - List of Items</u> .....	92
<u>1.8 - Skins - List of Items</u> .....	92
<u>1.9 - Enzyme Modified Cheese - List of Items</u> .....	93
<u>1.10 - Pastes and Slurries - List of Items</u> .....	93
<u>Appendix 2 - SQL Statements of Constraints and Restrictions</u> .....	94
<u>2.1 - Specialty Processed Cheese Department SQL Statement</u> .....	94
<u>Appendix 3 - Trials</u> .....	96
<u>3.1 - Procedures for Trials</u> .....	96
<u>3.1.1 - Procedure for Trials of Scheduling Strategies</u> .....	96
<u>3.1.2 - Procedure for Trials of Search Techniques</u> .....	97
<u>3.2 - Trials Results - Strategies Against Sequence Dependant Set-ups</u> .....	98
<u>3.2.1 - Due Date Sequence Only</u> .....	98
<u>3.2.2 - Batch Same Items</u> .....	99
<u>3.2.3 - Batch Same Formulations</u> .....	100
<u>3.2.4 - Batch Same Sizes</u> .....	101
<u>3.2.5 - Batch Same Groups</u> .....	102
<u>3.2.6 - Batch Same Odd Ball Groups</u> .....	103
<u>3.2.7 - Batch Same Groups, Then Same Items</u> .....	104
<u>3.2.8 - Batch Same Groups, Then Same Formulations</u> .....	105
<u>3.2.9 - Batch Same Groups, Then Same Sizes</u> .....	106
<u>3.2.10 - Batch Same Odd Ball Groups, Then Same Items</u> .....	107
<u>3.2.11 - Batch Same Odd Ball Groups, Then Same Formulations</u> .....	108
<u>3.2.12 - Batch Same Odd Ball Groups, Then Same Sizes</u> .....	109
<u>3.3 - Results of Trials of Search Techniques</u> .....	110
<u>3.3.1 - Branch and Bound</u> .....	110

<u>3.3.2 - Random Pair-wise Interchange</u> .....	111
<u>3.3.3 - Tabu Search</u> .....	112
<u>3.3.4 - Combination Individual Group Complete Enumeration and Tabu Search</u> .....	113
<u>Appendix 4 - Definitions of Terms Used</u> .....	114
<u>Bibliography</u> .....	118

## Table of Figures

<u>Figure 1 - Pastoral Foods Manufacturing Process</u> .....	6
<u>Figure 2 - Crew Rostering Gantt chart (Example)</u> .....	26
<u>Figure 3 - Master Production Schedule Procedure</u> .....	31
<u>Figure 4 - Procedure Flow Chart - Complete Enumeration</u> .....	39
<u>Figure 5 - Procedure Flow Chart Branch and Bound Map</u> .....	40
<u>Figure 6 - Procedure Flow Chart - Branch and Bound</u> .....	41
<u>Figure 7 - Graph of Results - Branch and Bound</u> .....	42
<u>Figure 8 - Procedure Flow Chart - Random Pair-Wise Interchange</u> .....	44
<u>Figure 9 - Graph of Results - Pair-Wise Interchange</u> .....	45
<u>Figure 10 - Procedure Flow Chart - Tabu Search</u> .....	48
<u>Figure 11 - Graph of Results - Tabu Search</u> .....	49
<u>Figure 12 - Graph of Results - Individual Group Enumeration and Tabu Search</u> .....	51
<u>Figure 13 - Pastoral Foods SOS Product Characteristics</u> .....	54
<u>Figure 14 - Pastoral Foods SOS Product Change Critical Path Diagram</u> .....	56
<u>Figure 15 - Gantt chart Interface - Pastoral Foods IWS Department</u> .....	67
<u>Figure 16 - Gantt chart Interface - Pastoral Foods SPC Department</u> .....	67
<u>Figure 17 - Groups v Time Buckets on Quantities - Pastoral Foods SPC Department</u> .....	69
<u>Figure 18 - Items v Time Buckets on Quantities - Pastoral Foods SPC Department</u> .....	70
<u>Figure 19 - Scheduling Tool - Main Scheduling Screen</u> .....	74
<u>Figure 20 - Scheduling Tool - Orders Listing</u> .....	76
<u>Figure 21 - Capacity Constraints and Restrictions - Pastoral Foods SPC Department</u> .....	77
<u>Figure 22 - Scheduling Tool - Recent Schedule Changes</u> .....	79
<u>Figure 23 - Capacity Constraints and Restrictions Available to Promise - Pastoral Foods SPC Department</u> .....	81

## List of Tables

<u>Table 1 – <i>Pastoral Foods</i> - Manufacturing lines and product types.....</u>	5
<u>Table 2 – Item versus Item Changeover Times Matrix (Example).....</u>	22
<u>Table 3 - Immunity From Disruption Example .....</u>	60